ENERGY EFFICIENCY OF THE BITCOIN MINING HARDWARE AND RELATED BLOCKCHAIN TECHNOLOGY

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Bachelor of Computer Science in Computer Systems & Networking.

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Pada masa kini, pelabur menggunakan bitcoin sebagai platform untuk melakukan transaksi seperti pertukaran wang tanpa melibatkan pihak ketiga ataupun bank berpusat. Bitcoin menjadi satu fenomena pada zaman moden ini namun penyelidikan yang lebih tertumpu kepada kecekapan kuasa bitcoin dan rangkaian blok (blockchain) adalah lebih sedikit daripada yang dijangka dalam konteks kesusateraan saintifik. Terutamanya dari segi kecekapan tenaga perkakasan untuk melombong bitcoin yang mana kecekapan tenaga dan penggunaan kuasa tidak dikira sebagai satu masalah dalam perlombongan bitcoin.

Pendekatan yang sedia ada dalam model teknologi bitcoin dan perkakasan untuk melombong bitcoin telah dianalisis melalui penyelidikan ini. Penyelidikan ini mencadangkan formula baru dan algoritma yang membenarkan penilaian kecekapan tenaga untuk perkakasan melombong bitcoin dibuat. MATLAB digunakan untuk membina dan mengesahkan algoritma. Set data diambil daripada sumber terbuka dan diaplikasikan dalam formula yang dicadangkan untuk menilai dan meramal kecekapan tenaga perkakasan dalam melombong bitcoin. Pengguna yang akan menggunakan formula dan algoritma yang dicadangkan ini adalah penaung sistem bitcoin dan pelombong bitcoin.

ABSTRACT

Nowadays, traders used bitcoin as a platform in making transaction such as exchanging money, without any involvement of a third party or central bank. Bitcoin becomes a phenomenon in this modernization era but the research devoted to the energy efficiency of bitcoins and related blockchain technology is still weakly considered in scientific literature. Especially the energy efficiency for the hardware of bitcoin mining were not considered as a problem in bitcoin mining.

The existing approaches in modelling the of bitcoin technology and the hardware of bitcoins were analyzed through this research. The research proposes new formula and algorithm which allows the evaluation of energy efficiency for the hardware of bitcoins mining. MATLAB is used in developing and validation the algorithm. Dataset was selected from open sources and applied in the proposed formula to evaluate and predict energy efficiency of bitcoin mining hardware. Developers of bitcoin hardware systems and bitcoin miners are the possible users of proposed formula and algorithm.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

$\mathcal{E}$	Energy Efficiency of Hardware
$	Cost
®	Registered Trademark
™	Trademark
P	Power Consumption
E	Energy Efficiency of Bitcoin
R	Hash Rate
P(t)	Power Consumption over Time
W	Power
D	Difficulty
T	Target
T_{max}	Largest Possible Value of Target
p	Probability (Nonce Value that yields Valid Hash)
R(t)	Hash Rate over Time
ϵ	Error Term
β_0	y-intercept
β_1	Slope / Regression Coefficient

LIST OF ABBREVIATIONS

MATLAB	Matrix Laboratory
GUI	Graphical User Interface
CPU	Central Processing Unit
GPU	Graphics Processing Unit
FPGA	Field Programmable Gate Arrays
ASIC	Application-Specific Integrated Circuits
CELL	Cell Broadband Engine Architecture
SSE2	Streaming SIMD Extensions 3

CHAPTER 1

INTRODUCTION

1.1 Overview

Nowadays, bitcoin has become a platform for traders in exchanging money without transactions involving central banks or other third party (Gervais, Karame, Capkun, & Capkun, 2014).

Bitcoin is a digital currency, which implementing encryption techniques to verify and validate any funds that have been transferred (Giungato, Rana, Tarabella, & Tricase, 2017). It is stored in a digital wallet which is very portable and difficult to counterfeit compared to the real money. Traders do not have to carry about any credit card or cash.

By using bitcoin, any transaction can be done easier and faster than usual even if the transaction made across the national border. Traders will not be charged for any transaction made in bitcoin system, unlike the transaction made via online banking. However, number of bitcoins are limited and currently only 21 million of bitcoins created through the bitcoin mining in the bitcoin cryptocurrency. This resulting in the increasing value of bitcoins which by some prognosis can reach a hundred million US dollars for a single bitcoin (Yermack, 2015). Huge companies such as Microsoft, Dell, PayPal and WordPress also use bitcoins as the platform to widen their business and to increase the profit of their companies.

On the other hand, blockchain is a digital record of ledger for transactions made in cryptocurrency which are stored in a chronological order (Crosby, Nachiappan, Pattanayak, Verma, & Kalyanaraman, 2016). Besides that, the record of ledger is shared publicly through the whole bitcoin network (Lewis, 2015). There is a list of records (called blocks), which is gradually growing, using cryptography to guarantee the security of the bitcoin cryptocurrency. Each block contains the data of a transaction made, a

timestamp and a cryptographic hash, which is a mathematical algorithm performing a one-way function in the cryptography (Nakamoto, 2008).

Apart from that, the energy efficiency of bitcoin mining hardware and related blockchain technology also help in reducing the demands of energy consumes in preventing the double spending of bitcoin. The more efficiency the energy of hardware, the lesser the energy consumes throughout the process of bitcoin transaction (Karame, Androulaki, & Capkun, 2012).

This resulting in the types of hardware used in the mining of bitcoin where the hardware which provide much efficiency in terms of energy and power consumption is preferable in the market of bitcoin mining.

1.2 Problem Statement

The problem of energy efficiency of hardware used for bitcoin mining was weakly considered in scientific literature. Several existing formulas not focusing on the energy efficiency of hardware for bitcoin mining. Existing formulas do not allow to predict trends of bitcoin mining hardware.

1.3 Objective

Based on the problem statement, the objectives of this research are:

i. To analyse existing approaches for the modelling energy efficiency of the bitcoin mining hardware and related blockchain technology.

ii. To develop the model allowing to predict an energy efficiency of the hardware of bitcoins mining.

iii. To evaluate the model on the existing datasets for energy efficiency of bitcoin mining in terms of hardware.

1.4 Scope

i. This research focuses on the current trends of energy efficiency of hardware used for bitcoin mining.

ii. Users of proposed formula and the algorithm are the developers of bitcoin hardware systems and bitcoin miners.

iii. For the algorithm development, MATLAB is used.

iv. Linear Regression method is used for trends analyses.

v. Proposed formula takes into account four parameters which are the year, energy efficiency, hash rate and power consumption.

vi. Validation is based on open data sets available at www.blockchain.info, www.tradeblock.com and https://en.bitcoin.it/wiki.

1.5 Thesis Organization

This thesis consists of 5 chapters which are Introduction, Literature Review, Methodology, Result and Discussion and Conclusion. Chapter 1 briefly describes the introduction of bitcoin systems. It also includes the problems within the bitcoin systems which are related to this research. Besides that, this chapter presents the objective, scope of research, and the organization of the thesis.

Chapter 2 gives a systematic literature review. The literature review describes the studies related to this research. In this chapter, the selected research studies are compared to each other to find the existing approaches for modelling sustainability. Then, the analysed approaches that will be used throughout this research.

Chapter 3 describes the methodology used in this research such as systematic literature review, development of model and its validation based on the data obtained from the open sources (energy efficiency and power consumption of the bitcoin mining).

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